Interaction of Retronasal and Orthonasal Perception of Unfamiliar Flavors

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Abstract:

Aroma compounds can be perceived through orthonasal (through the nose—smelling) or retronasal (through the mouth—flavor) mechanisms. These signals are processed by the same receptors and by the same sections of the brain, but are thought to elicit different perceptions, hedonic responses and behaviors. In this experiment, sensory evaluation of unfamiliar flavors by retronasal (flavor) and orthonasal (smell) perception were studied. The unfamiliar flavors used were Yuzu, Carambola, Hibiscus, and Momo. A matching test wherein panelists were given a reference sample containing one of the aroma compounds and told to identify that sample amongst the four unknowns was performed for three different evaluation scenarios: orthonasal to orthonasal perception, retronasal to retronasal perception, and retronasal to orthonasal perception. For each condition, the probability of a panelist correctly guessing all of the matching samples is 0.39%. McNemar's Test for Correlated Proportions was used to identify significant differences in correct responses for the three conditions. When data from all flavors were combined, retronasal to orthonasal matching proved to be most difficult. Indeed, significantly more samples were correctly matched when reference and target samples were both evaluated retronasally (retronasal-retronasal; $p=0.039$). This difference approached significance ($p=0.062$) when the reference and target samples were both presented orthonasally. For the Carambola and Momo flavors, significantly fewer retronasal-orthonasal matches were made compared to the orthonasal-orthonasal evaluations ($p=0.020$ and $p=0.038$, respectively) and retronasal-retronasal evaluations ($p=.003$ and 0.008; respectively). Hibiscus and Yuzu only showed significant differences when comparing the orthonasal-orthonasal condition to the retronasal-orthonasal condition ($p=0.038$, $p=0.043$). Overall, these results can be used in the flavor and food industry in order to better understand how the application of aromatic flavors leads to different perceptions by consumers when evaluated by nose or by mouth.

Introduction:

The human brain utilizes many senses to interpret the environment, but olfaction is the only dual sense, meaning that aroma compounds can be perceived in two different ways: retronasally and orthonasally (1). Olfaction is a dual sense in that the smell and mouth perceptions are closely related; this interaction can be seen through one's interpretation of an external stimulus (smell) and associating it with the stimulus of an internal response, like an illness associated with eating or digesting the food associated with the smell (3). Retronasal perception occurs through the mouth and is commonly associated with flavor (1). Flavor can be defined in the Oxford English Dictionary as "the element in the taste of a substance which depends on the cooperation of the sense of smell", indicating that retronasal and orthonasal perceptions are related (3). Retronasal perception has to deal with the internal world, pertaining to odorants that are internalized and could cause harm or a reaction within the body, both beneficial and not beneficial (1). "Taste" is also associated with the concept of flavor but only includes purely gustatory properties like sweetness, saltiness, sourness, or bitterness (3). In previous studies, when comparing the orthonasal to retronasal odor perception, gustatory stimuli were eliminated in order to evaluate a purely orthonasal or retronasal stimulus perception (4); with the addition of a gustatory stimulus, orthonasal and retronasal perceptions become more equally identifiable (4). Orthonasal perception has to deal with the external world, pertaining to events occurring outside the body (1). Orthonasal perception is much more sensitive than retronasal perception (2). Even though olfaction is a dual sense, the signals are processed in a same section of the brain (2). However, these signals are thought to elicit different perceptions, hedonic responses, and behaviors. Because the same stimulus delivered through the nose or through the mouth can produce different sensations, matching a reference and target stimulus should be more difficult when delivered through different routes (retronasal-orthonasal) than when delivered by the same routes (orthonasal-orthonasal or retronasal-retronasal).

The objective of this experiment was to determine if subjects' ability to correctly match unfamiliar aromas was better in the orthonasal-orthonasal or retronasal-

retronasal conditions compared to the retronasal-orthonasal condition. Panelists were hypothesized to correctly match the most aromas when both the reference and target were delivered in the orthonasal condition because orthonasal perception is most sensitive. Flavor matching in the retronasal-retronasal condition was hypothesized to be less conclusive because of decreased sensitivity to aroma compounds. It was also hypothesized that panelists would perform worst in the retronasal-orthonasal condition because different sensations were expected to be elicited by the different routes of delivery.

Materials and Methods:

In this experiment, four unknown flavor compounds were used in application by various concentrations in distilled water: Yuzu (Givaudan, Cincinnati, OH), Hibiscus (Givaudan, Cincinnati, OH), Passion fruit (Givaudan, Cincinnati, OH), and Peach (Wild Flavor, Erlanger, KY). Passion fruit was relabeled as Carambola and Peach was relabeled as Momo.

Table 1: Retronasal and Orthonasal Concentration Levels for Unfamiliar Flavors

Flavor	Retronasal Concentration Level[d]	Orthonasal Concentration Level[d]
Yuzu	0.60%[b]	0.10%[b]
Hibiscus	0.80%[b]	0.35%[b]
Passion fruit (Carambola)[a]	0.35%[b]	0.24%[b]
Peach (Momo)[a]	0.15%[c]	0.05%[c]

[a]Names were used in experiment in order to present to panelists a flavor name that was unfamiliar to them

[b]Concentrated solutions were created on a volume-by-volume basis (volume ml flavor/ volume ml water)

[c]Concentrated solutions were created on a weight by volume basis (weight g flavor/ volume ml water)

[d]All concentration levels were set to create an equivalent intensity perception across flavor types as well as across evaluation conditions (orthonasal and retronasal)

Thirty panelists, recruited from the Parker Food Science building in Columbus, OH, were sampled for all three conditions. Each panelist was presented with the three conditions (orthonasal to orthonasal, retronasal to retronasal, or retronasal to orthonasal) in random order. Panelist responses were collected on a paper ballot.

The panelists were all given water and crackers in order to ensure a clean pallet for each test set and to eliminate previous confounding flavors or odors. For each condition, a reference sample was presented along with four unknown samples containing the target (same as the reference) and the three other samples which served as distractors. All samples were presented simultaneously for a total of 20 samples for each set of evaluation conditions. Presentation of the reference and target/distractor samples was randomized in order to eliminate any bias by the panelists. The target/distractor samples were each given a random three-digit number, and the panelists were asked to identify the sample that matched the reference by recording the three-digit number on the ballot. These results were then compiled for correct responses from the panelists for each condition and for each unfamiliar flavor. A McNemar's Test for Correlated Proportions, with a significance level of alpha equaling 0.05, was run in order to determine if a significantly higher proportion of correct matches were obtained in the orthonasal-orthonasal or retronasal-retronasal conditions compared to the retronasal-orthonasal condition. This analysis was run for the combined flavor data set as well as for each individual flavor.

Results:

According to the overall results, the percent of correct responses from each condition was not significantly different between the orthonasal-orthonasal condition and the retronasal-retronasal condition (Figure 1). When compared to the two control conditions (orthonasal-orthonasal and retronasal-retronasal), significantly fewer correct matches were obtained in the retronasal-orthonasal condition (Figure 1).

Carambola and Momo were both flavors with non-significant differences when comparing the number of correct matches between the orthonasal-orthonasal and retronasal-retronasal condition but were significantly different when these like-like conditions were compared to the retronasal-retronasal condition (Table 2, Figure 2). When comparing the correct number of matches using the Hibiscus and Yuzu flavors, significant differences were obtained between the orthonasal-orthonasal and retronasal-orthonasal condition only (Table 2, Figure 2).

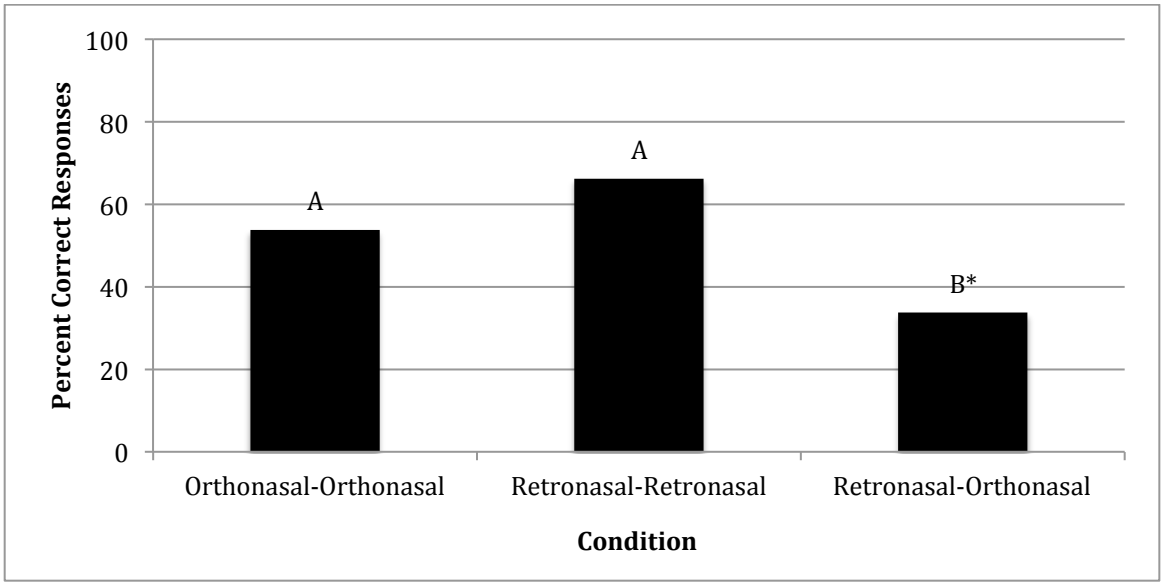

Figure 1: Percent correct responses from panelists in each condition: orthonasal-orthonasal, retronasal-retronasal, retronasal-orthonasal

[AB]Supercripts over each data bar indicate presence or absence of significant differences. Bars having different superscripts are significantly different for the conditions

**The orthonasal-orthonasal and retronasal-orthonasal conditions are marginally significantly different (p=0.062)*

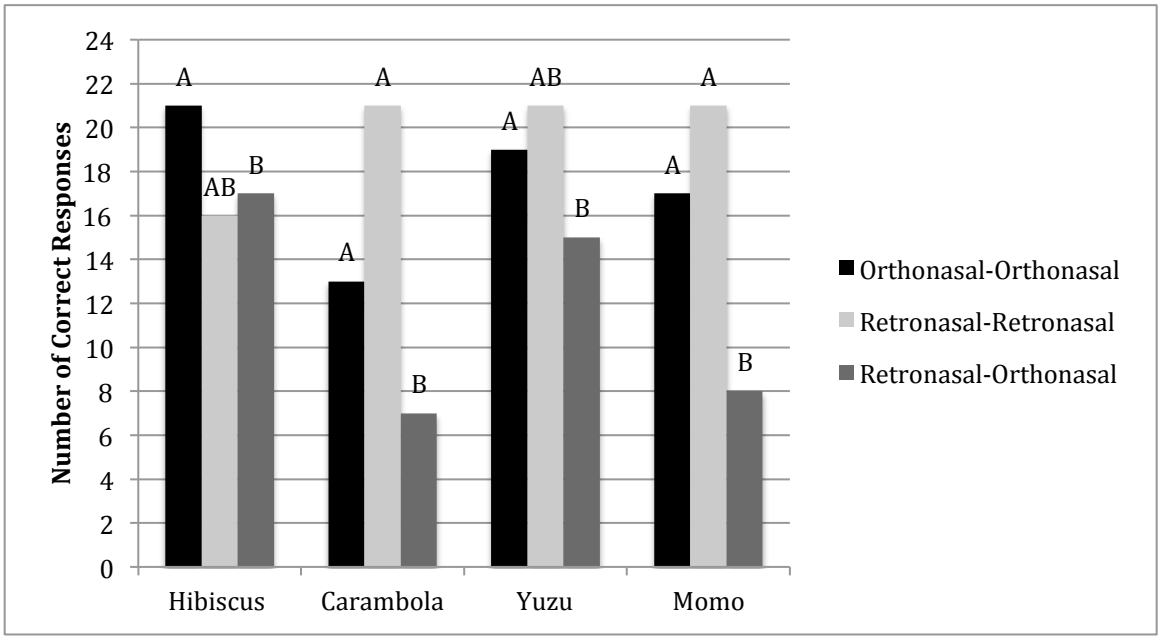

Figure 2: Correct identification of unfamiliar flavors by orthonasal-orthonasal, retronasal-retronasal, or retronasal-orthonasal perception

[AB]Superscripts over each data bar indicate significant or non-significant differences. If two bars have different superscripts above them then the data is significantly different for the conditions

Table 2: McNemar's test p-values for significant differences between success of the overall conditions and between each condition for each flavor

	Condition		
	Orthonasal-orthonasal / Retronasal-retronasal	Orthonasal-orthonasal / Retronasal-orthonasal	Retronasal-retronasal / Retronasal-Orthonasal
Hibiscus	0.180	0.038[a]	0.090
Carambola	0.080	0.020[a]	0.003[a]
Yuzu	0.607	0.043[a]	0.118
Momo	0.332	0.038[a]	0.008[a]
Overall	0.999	0.062[b]	0.039[a]

[a]P-value indicates significantly different using 0.05 for alpha value
[b]P-value indicates marginally significantly different

When looking at the number of correct responses for the orthonasal-orthonasal condition, Carambola had the least number of correct responses and Hibiscus had the greatest number of correct responses (Figure 2). When looking at the number of correct responses for the retronasal-retronasal condition, Carambola, Yuzu, and Momo had the greatest number of correct responses and Hibiscus had the least number of correct responses (Figure 2). When looking at the number of correct responses for the retronasal-orthonasal condition, Carambola had the least number of correct responses and Hibiscus has the greatest number of correct responses (Figure 2).

Discussion:

According to **Figure 1**, the retronasal-orthonasal flavor perception condition proved to be the most difficult condition for panelists to correctly identify the unknown flavors overall. Momo and Carambola flavors proved that the retronasal-orthonasal condition is significantly different from the orthonasal-orthonasal and retronasal-retronasal conditions (Table 2). This indicates that there may be a more distinctive attribute in each of these flavors that panelists were able to identify than in the other unfamiliar flavors. Hibiscus and Yuzu produced significantly different data in the number of correct responses by McNemar's test when comparing orthonasal-orthonasal and retronasal-orthonasal conditions; the p-values for significance between the retronasal-retronasal and retronasal-orthonasal conditions were close to the 0.05 alpha value (Table 2). Overall, the percent of correct responses for the

retronasal-retronasal condition was greater than that of the other conditions (Figure 1). This is surprising given the increased sensitivity often associated with orthonasal evaluations. However, the presence of taste or gustatory sensations evoked by the flavorants may have aided panelists in matching stimuli in the retronasal-retronasal condition. This confound could be eliminated in future experiments by delivering airphase stimuli directly to the retronasal receptors instead of through aqueous solutions.

Conclusions and Future Research:

With the same methods and materials being altered, the effect of changing to familiar flavors should also be analyzed; it is predicted that because panelists may have previous cognitive memories of the flavor attributes, it will produce a greater number of correct responses in all conditions. A subject may not need to match the flavor profile presented, but rather would choose the flavor that is closest to their familiar flavor concept (e.g. identifying a sample that is closest to an orange flavor). Using the same methods again with different materials, known flavors with similar but different attributes (e.g. different types of coffee) should be analyzed in order to compare to the data collected in this experiment. In order to create more power for the test, the same panelists should be used to perform these two other flavor experiments. A greater number of panelists could also create more power for the experiment.

Overall, the retronasal-orthonasal condition produced significantly different results from the two conditions of orthonasal-orthonasal and retronasal-retronasal and the panelists were less successful in unfamiliar flavor matching from retronasal perception to orthonasal perception. By application in the food industry, this information can be useful in understanding how certain compounds or volatile aromatics are perceived in application of different food items, like a beverage in the case of this study.

References:

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